

What Is Claimed Is:

1 1. A method of etching a dielectric layer with selectivity to an
2 underlying stop layer, comprising:
3 supporting a semiconductor substrate in a plasma etch reactor, the
4 substrate including a dielectric layer over a stop layer;
5 supplying an etchant gas to the plasma etch chamber; and
6 etching openings in the dielectric layer by energizing the etchant gas into
7 a plasma state, the etchant gas comprising a hydrogen-free fluorocarbon gas
8 represented by C_xF_y gas wherein $y/x \leq 1.5$, an oxygen-containing gas and optional
9 carrier gas.

1 2. The method of Claim 1, wherein the openings comprise vias,
2 contacts, and/or trenches of a dual damascene structure, a self-aligned contact
3 (SAC) structure or self-aligned trench structure.

1 3. The method of Claim 1, wherein the stop layer is silicon nitride
2 and the etch rate selectivity of the dielectric to the silicon nitride is at least 10.

1 4. The method of Claim 1, wherein the dielectric layer comprises
2 doped or undoped silicon oxide layer or low-k material and the stop layer
3 comprises a silicon nitride layer.

1 5. The method of Claim 1, wherein the plasma etch reactor
2 comprises an ECR plasma reactor, an inductively coupled plasma reactor, a
3 capacitively coupled plasma reactor, a helicon plasma reactor or a magnetron
4 plasma reactor.

1 6. The method of Claim 1, wherein the plasma etch reactor
2 comprises a dual frequency capacitively coupled plasma reactor including an upper
3 showerhead electrode and a bottom electrode, RF energy being supplied at two
4 different frequencies to either the bottom electrode or at different first and second
5 frequencies to the showerhead electrode and bottom electrode.

1 7. The method of Claim 1, wherein the etchant gas is nitrogen-free,
2 the C_xF_y gas is at least C_4F_6 , the oxygen containing gas is at least O_2 and the
3 carrier gas is Ar, the etchant gas being supplied to the plasma etch reactor through
4 a showerhead electrode at flow rates of 2 to 50 sccm C_4F_6 , 2 to 50 sccm O_2 and 50
5 to 800 sccm Ar.

1 8. The method of Claim 1, wherein the C_xF_y gas is at least C_4F_6 , the
2 oxygen containing gas is at least O_2 and the carrier gas is Ar, the etchant gas being
3 supplied to the plasma etch reactor through a showerhead electrode at flow rates of
4 10 to 25 sccm C_4F_6 , 5 to 20 sccm O_2 and 50 to 300 sccm Ar.

1 9. The method of Claim 1, wherein a ratio of flow rates of the C_xF_y
2 to oxygen containing reactant is 0.5:1 to 5:1.

1 10. The method of Claim 1, wherein a ratio of flow rates of the C_xF_y
2 to oxygen containing reactant is 1:1 to 2:1.

1 11. The method of Claim 1, wherein pressure in the plasma etch
2 reactor is 10 to 200 mTorr and/or temperature of the substrate support is $-20^{\circ}C$ to
3 $+80^{\circ}C$.

1 12. The method of Claim 1, wherein pressure in the plasma etch
2 reactor is 50 to 100 mTorr and/or temperature of the substrate support is $+20^{\circ}C$
3 to $+60^{\circ}C$.

1 13. The method of Claim 1, wherein the plasma etch reactor is a
2 capacitively coupled plasma reactor having a powered showerhead electrode and/or

3 a powered bottom electrode, the showerhead electrode being supplied 0 to 3000
4 watts of RF energy and the bottom electrode being supplied 0 to 3000 watts of RF
5 energy.

1 14. The method of Claim 1, wherein the etchant gas includes CO
2 supplied to the plasma etch reactor at a rate of 50 to 500 sccm CO.

1 15. The method of Claim 1, wherein the C_xF_y is either C_4F_6 or C_6F_6 .

1 16. The method of Claim 1, wherein the C_xF_y is C_4F_6 and the oxygen
2 containing gas is O_2 , the C_4F_6 and O_2 being supplied to the plasma etch reactor at
3 flow rates having a ratio of $C_4F_6:O_2$ of 0.5:1 to 5:1.

1 17. The method of Claim 1, wherein the C_xF_y is C_4F_6 and the oxygen
2 containing gas is O_2 , the C_4F_6 and O_2 being supplied to the plasma etch reactor at
3 flow rates having a ratio of $C_4F_6:O_2$ of 1:1 to 2:1.

1 18. The method of Claim 1, wherein the C_xF_y is C_4F_6 and the oxygen
2 containing gas is supplied to the plasma etch chamber in an amount sufficient to
3 avoid etch stop during etching of the openings.

1 19. The method of Claim 1, wherein the etched openings open onto
2 flat and corner portions of the stop layer, the dielectric layer comprises BPSG and
3 the stop layer comprises silicon nitride, the etch rate selectivity of the BPSG to the
4 flat and corner portions of tyhe silicon nitride being at least 15.

1 20. The method of Claim 1, wherein the dielectric layer comprises
2 BPSG and the stop layer comprises silicon nitride, the C_xF_y gas being C_4F_6 and the
3 oxygen containing gas being O_2 , the C_4F_6 and O_2 being supplied to the plasma etch
4 reactor at flow rates having a ratio of $O_2:C_4F_6$ of 0.5 to 1.2.